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ABSTRACT

There is considerable disagreement concerning the age of onset and universality of attainment of Piaget's stage of formal operations. This study examines developmental differences in response to brief prompts in the use of a formal operational approach to the solution of two tasks. The subjects were 10 males and 10 females from each of Grades 5, 8, and 12. Three tasks requiring the formal operational skill of separating and testing variables were given to each subject. Results suggest that almost all the subjects could readily understand and utilize the approach of separating variables and testing each one while holding all others constant. Furthermore, the results support Piaget's claim that formal operations are available to nearly all normal young adults. Implications for the development of logical competence are discussed. (SJL)

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Eliciting Formal Operations

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Two formal operations tasks were presented to children from grades five, eight, and twelve--first, in the open-ended fashion used by Inhelder and Piaget and then with prompts in the use of a formal operational strategy. None of the young subjects and less than half of the older subjects were able to solve the first task on their own. A few of the younger subjects and nearly all of the adolescents, however, performed at a formal operational level on a transfer task. Eliciting formal operations by prompting and then measuring transfer appears to be a promising method for assessing logical competence.

Eliciting Formal Operations

Fred W. Danner and Mary Carol Day

There is considerable disagreement concerning the age of onset and universality of attainment of Piaget's stage of formal operations. Inhelder and Piaget's major work on this topic (Inhelder & Piaget, 1958) indicates that formal operations begin to emerge at around the age of eleven and, since all of the adolescent protocols in their book serve as examples of formal operations, it leaves most readers with the impression that formal operational thinking is the rule in adolescence. Many replications of Inhelder and Piaget's experiments, however, indicate that adolescents and even adults have trouble solving the problems which Piaget used to assess formal operations (cf., Papalia & Bielby, 1974; Schwebel, 1975; Tomlinson-Keasey, 1972). Often, less than half of the adult subjects in such replications appear to have attained formal operations. These findings have led many investigators to conclude that the stage of formal operations as described by Piaget emerges much later than he originally estimated and is far from universal (Niemark, 1975; Riegel, 1973).

In a recent paper, Piaget acknowledged the failure to find evidence for the use of formal operations in the test performance of many adults but rejected the notion that formal operations constitute a set of specialized aptitudes which only a small percentage of adults possess (Piaget, 1972). He reiterated his earlier position

that all normal individuals eventually attain formal operations and attributed the failure of many adults to display formal operational skills to their lack of familiarity with the scientific tasks typically used to assess these skills. In other words, Piaget claims that adults possess formal operational skills which are often not elicited by unfamiliar and ambiguous tasks.

If the typical formal operations tasks are so unfamiliar that they fail to elicit optimum performance from adults, it seems likely that they might also underestimate the logical abilities of children. So how might one get a more accurate assessment of the development of formal operational skills? Two approaches which follow from Piaget's lack of familiarity argument are one, devise tasks requiring formal operations within each subject's particular area of interest or two, try to make the demands of the typical formal operations tasks more clear. We have chosen the second approach and are studying developmental differences in response to brief prompts in the use of a formal operational approach to the solution of two tasks. We hypothesized that these prompts would clarify task demands for older adolescents and therefore elicit the use of formal operations on a transfer task. We also predicted that younger subjects would improve less because they would be less likely to possess the logical skills we were attempting to elicit.

Method

Subjects. The subjects were 10 males and 10 females from each of grades 5, 8, and 12 who were randomly selected from two schools in a middle income urban area. Intelligence and achievement test data were not available. The age range of the subjects at each

grade level was as follows: grade 5, 9-11 to 11-0, grade 8, 13-1 to 14-3, and grade 12, 17-0 to 18-2.

Tasks and Procedure. Each subject was individually tested on the following three tasks in a single one-hour session: the flexibility of rods and pendulum tasks used by Inhelder and Piaget and a spinning wheels task adapted from a similar task used by Case (1974). The order of task presentation was counter-balanced with the exception that the spinning wheels task was always second. Each of these tasks required the separation and systematic testing of four variables. The flexibility of rods task, for example, consisted of rods which differed in length, diameter, material, and point of attachment of a small weight. The subject was given two equal weights and was asked to hang them on the rods, compare the degree to which they bent, and, by doing so, figure out which factors influence bending. In order to solve the task, the subject had to test for the effects of each variable separately while holding all other factors constant. On all three tasks, the subject was simply asked to find out which factors influence the phenomenon in question. This open-ended procedure corresponds to that used by Inhelder and Piaget. A record was made of the comparisons which subjects made and the conclusions they drew from each comparison. On the first two tasks, a series of prompts were given after the subject had first attempted to solve the problem on his own. The order of prompts was a follows:

1) E named any variable S had not tested and asked him to test it.

2) Verbal Rule: The subject was told that a good way to figure out which factors matter was to make sure that everything was the same except the one thing he was testing.

3) Verbal Rule + Example: The verbal rule was repeated and an example was given to demonstrate its use.

4) Direct Prompt: E asked S for a test of each variable in turn and reminded him each time to hold all other variables constant.

5) E conducted all four tests while S watched.

Each subject was given prompts until he had made unconfounded tests of all variables or until the experimenter finally demonstrated the unconfounded tests for him.

In summary, three tasks requiring the formal operational skill of separating and testing variables were given to each subject. The subject was first asked to solve each task on his own and then, on the first two tasks, he was prompted to separate and test each variable while holding the others constant. The major comparison of interest was that between unaided performance on task one and unaided performance on task three, which reflects the influence of the intervening prompts on tasks one and two. The four variables on each task were scored as either having been correctly tested or confounded with other variables.

Results and Discussion

Inhelder and Piaget (1958) describe two categories of formal operational performance--one involving perfect performance, i.e., all variables separated and tested correctly, and one allowing for an unspecified degree of error. We also applied two criteria to the performance of our subjects. The strict criterion required that all four variables on each task be separated and tested with no confounding. The lax criterion for formal operations allowed the subject to

confound one test out of four. These two criteria were applied to the data on the unprompted performance of subjects on all three tasks with the following results:

Percentage of Subjects Demonstrating Formal Operations

	Task 1		Task 2		Task 3	
	Strict	Lax	Strict	Lax	Strict	Lax
Age 10	0	0	5	15	15	30
Age 13	25	45	50	70	65	85
Age 18	35	55	45	80	85	95

On task one, before any prompting, all three age groups performed in a manner consistent with most replications of Piaget's formal operations experiments, that is, the 10-year-olds did not systematically separate and test variables, approximately one third of the 13-year-olds did, and only about half of the 18-year-olds did. On task three, however, a few of the 10-year-olds and nearly all of the adolescents performed at a formal operational level. These results and post-experiment interviews lead us to believe that almost all of our adolescent subjects could easily understand and utilize the approach of separating variables and testing each one while holding all others constant. The fact that less than half of them did so on the first task suggests that the open-ended format typically used on formal operations tasks grossly underestimates their logical competence. In fact, many of the 13- and 18-year-old subjects who failed to solve the first task without prompting reported that they thought it required a more complex approach involving multiple comparisons of variables.

The results of the present experiment support Piaget's claim that formal operations, as evidenced by the scheme of holding all other factors constant while testing the effects of one variable at a time, are available to nearly all normal young adults. These results suggest that much of the empirical-descriptive work on the development of formal operations and the frequency of their appearance in adult populations overestimates the age of on set and underestimates the frequency of occurrence of these skills. Furthermore, the method used in this experiment eliciting formal operations and then assessing transfer--appears to be sensitive to age differences in competence. This method, together with training studies such as that by Siegler and Liebert (1975), is likely to provide a more accurate assessment of logical competence and its development than has been available to date.

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